INTER-SPECIES VARIATION IN COLOUR PERCEPTION

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1. THE ARGUMENT FROM PERCEPTUAL VARIATION

Familiar facts about perceptual variation presents a long standing problem for the view that colours are mind-independent properties. To say that colours are mind-independent is to say that what it is to be a colour is constitutively independent of the experiences of appropriately constituted, appropriately situated, perceiving subjects; or more roughly speaking, that colours are one thing, and experiences of colour another. There are a number of more specific theories of the nature of colour are consistent with the claim that colours are mind-independent: physicalists, for instance, identify colours with properties that can be described using the vocabulary of a more or less narrowly circumscribed physical theory, typically types of surface reflectance property (e.g. Byrne and Hilbert 2003) or else the underlying microphysical grounds of these reflectance properties (e.g. Jackson 1998), whereas naïve realists (or primitivists, e.g. Campbell 1993) think of colours as distinct *sui generis* properties. Either way, it follows from the claim that colours are mind-independent that there is a sharp distinction between the colour an object really *is* and the colour it merely *appears* when the conditions necessary for its veridical perception do not obtain.

It is the commitment to a sharp appearance-reality distinction for the colours to which facts about perceptual variation present the well known challenge. If the colour an object appears varies between subjects and across conditions of perception, then which subjects, in which perceptual conditions, perceive the object's colour as it really is? In the absence of a non-arbitrary reason to prefer one set of perceivers and one set of perceptual conditions, the distinction between appearance and reality threatens to collapse. Assuming that the object cannot really be all the colours that it variously appears, the egalitarian response would seem to be to deny that the object is really any of the colours it appears.

Reconstructed slightly more explicitly, the general form of the *Argument from Perceptual Variation* runs as follows:

(1) an object x appears *F* to subject S and appears *G* to subject S* (or: appears *F*
to subject S in conditions C and appears *G* to S in conditions C*)
(2) *F* and *G* are incompatible: x cannot be both *F* and *G*;
(3) there is no non-arbitrary reason to suppose that x really is *F* and merely appears *G*; conversely, there is no non-arbitrary reason to suppose that x merely appears *F* and really is *G*;
(4) therefore, x is really neither *F* nor *G*: *F* and *G* are both equally apparent.

Many different kinds of perceptual variation can be plugged into this general argumentative schema. Indeed, as Berkeley's famous use of this argumentative strategy in the *First Dialogue* illustrates, the argument can be extended beyond cases of perceptual variation involving the perception of colour, and even the traditional class of secondary qualities, to perceptual variation involving primary qualities such as shape, size and motion as well. A particularly compelling instance of this argumentative strategy, however, concerns differences in perceived colour between members of different species. Members of different species appear to differ not just in the more specific colour distinctions that they make, but also in the very *kinds* of colour that they are able to perceive. This raises with a vengeance the question of which subjects perceive colours as they really are.

Some details of differences in colour perception found across the animal kingdom are presented in §2. A selection of possible responses to the inter-species version of the Argument from Perceptual Variation are outlined in §3. I suggest that the most promising option is to deny premiss (2) of the Argument: the claim that members of different species perceive properties that are mutually incompatible. One way of rejecting this premiss is developed in §4: employing the distinction between determinates and determinables, I argue that the colours that members of different species perceive are determinates of different determinables, and as such, mutually compatible. The remaining sections then address some objections to the 'selectionist' strategy of which this response is an instance: §5 considers whether rejecting premiss (2) of the Argument from Perceptual Variation is consistent with the claim that colours are mind-independent properties; §6 is concerned with the ontological commitment of selectionist theories; and §7 addresses the issue of what sense the properties that different species select can properly be called colours at all.

2. The Birds and the Bees

Colour vision varies dramatically across the animal kingdom. On the one hand, members of different species differ markedly in the extent of the electromagnetic spectrum to which they are sensitive. Humans are sensitive to light of between roughly 400 and 700 nanometres (nms). The visible window for bees is shifted into the near ultra-violet, ranging from 300 to 650nms. Still other creatures, like salmon, can perceive light in the infra-red region of the spectrum. And the visible window of some creatures, including diurnal birds like the pigeon, extends into both the ultra-violet and infra-red regions of the spectrum, spanning 350 to 720nms.

Cross-cutting differences in their sensitivity to regions of the electromagnetic spectrum, different species vary more fundamentally in the dimensionality of their colour vision. The human eye contains three types of retinal receptor, each sensitive to different, but overlapping, broadband spectral

frequencies. The result is that humans are able to colour match any given spectral stimulus with just three appropriately chosen (visible-to-humans) spectral lights, a feature of the visual system know as *trichromacy*. Human colour vision is not unique in being trichromatic: bees, macaque monkeys, and many other creatures also enjoy trichromatic colour vision. Trichromacy, however, is by no means standard. Cats, squirrels and rabbits, for instance are *dichromatic*: they have eyes that contain just two kinds of retinal receptor, and so require just two appropriately chosen spectral lights to match any given spectral stimulus. *Monochromatic* creatures lack chromatic colour vision entirely, being able to colour match any given spectral stimulus with any other. In still further contrast, pigeons, goldfish, and ducks have eyes containing at least four types of retinal receptor. As such, their colour vision is at least *tetrachromatic*: it takes at least four appropriately chosen spectral lights to match any given spectral stimulus (Jacobs 1981 and Thompson 1995: 141-60).

The dimensionality of a subject's visual system constrains the nature of the colour experience the subject enjoys, but does not fully determine it. The phenomenology of a subject's eventual colour experience further depends on the way in which signals from their retinal receptors are subsequently processed. Again, there appear to be significant inter-species variation in this respect.

In humans, the signals from the three retinal receptor types are processed in three neurophysiologically realised, opponently organised, psychophysical channels. The resulting colour experiences can be described in a multi-dimensional colour space. Although the details are by no means uncontroversial, this is standardly thought of as a three-dimensional space whose axes are *hue*, *saturation* and *lightness*:

> *hue* describes whether the perceived colour appears to be red, yellow, green, blue, or some phenomenal mixture of these, i.e. orange, chartreuse, cyan, purple, etc.;
>
> *saturation* describes the proportion of the perceived colour's hue relative to its lightness;
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> *lightness* describes the intensity of the light that the coloured object appears to reflect.[1]

[1] The nature, and even number, of the dimensions of colour space is controversial. The use of hue, saturation and lightness to describe colours-as-they-appear, for instance, extends the use of these terms to describe purely physical stimuli. Whether this extension is appropriate is far from clear. Indeed, it is not even clear that three dimensions are sufficient to completely describe colours-as-they-appear: at least as far as colours of material objects in an illuminated scene are concerned, for instance, we are able to distinguish between an object's *lightness*, or where it is located on the series of achromatic colours ranging from white to black, and its *brightness*, or how well it is illuminated. For discussion, see e.g. Mausfeld (2005). Without wanting to prejudge any of these empirical questions, I will continue to talk of human colour space as a three-dimensional space whose axes are hue, saturation and lightness; but these axes should be understood as placeholders for the axes that turn out to best characterise colour space. This should not affect the main argument of the paper, as any problems describing human colour space will have analogues in the inter-species case: if, for instance, more than three-

Neither the physiology or psychophysics of colour vision in other species is known in as much detail, but there is evidence to suggest that the processing of retinal signals varies significantly across different species, and that the eventual colour experiences differ radically as a result. In the case of the pigeon, for instance—one of the species on which a significant amount of empirical work has been conducted—the signals from the retinal receptors appear to be opponently processed in at least *four* neurophysiologically realised psychophysical channels. It is natural to speculate that even if this does not bring with it a net gain in the bare number of colour discriminations that pigeons are able to make, it will at least give rise to more kinds of colour experiences than humans enjoy.

In humans, post-retinal opponent-processing results in a division of perceived colour into two mutually exclusive categories: *elemental* and *compound*. Corresponding to the three opponently organised psychophysical channels in which signals from the retinal receptors are processed, human colour space contains six elemental colours: the hues red, green, blue, yellow, and (at least by extension) the achromatic colours black and white. The elemental colours enjoy a special psychological status. Admitting of instances that are 'unique' (or 'phenomenally uncomposed'), the elemental colours are minimally sufficient for the description of all other colour samples: so, for instance, we can describe orange in terms of red and yellow, chartreuse in terms of yellow and green, pink in terms of red and white, grey in terms of black and white, and so on. Compound colours, in contrast—the binary hues orange, chartreuse, cyan and purple, the achromatic greys, and darkened or lightened hues like brown, olive, pink—do not enjoy the same landmark status. Compound colours are phenomenally composed of at least two other colours. A corollary of this is that the compound colours are not generally sufficient for the description of other colours: for instance, it is not natural to describe red as a mixture of orange and purple in the way that it is natural to describe orange as a mixture of red and yellow.

Corresponding to the extra psychophysical channel in which the signals from their extra type of retinal receptor are processed, it seems natural to assume that pigeons have a colour space that contains two more elemental colours than human colour space. This would bring the total number of elemental colours that pigeons perceive to eight. It would also bring with it a corresponding increase in the number of compound colours that pigeons can perceive. It might even lead pigeons to perceive a completely different kind of colour, 'ternary hues', which would be like our binary hues, but instead of being phenomenally composed of two elemental hues, they would be phenomenally composed of three elemental hues: roughly speaking, perceiving a ternary hue would be the equivalent of

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dimensions (like brightness, in addition to lightness) are needed to describe human colour space, then they are likely to have analogues in the colour spaces of members of other species.

perceiving something that is a phenomenal mixture of red, green *and* blue (Hardin 1988: 146, Thompson 1995: 158).

3. Responses

Accommodating differences in colour perception between members of different species poses a serious problem for the view that colours are mind-independent.

It does not seem especially attractive to deny premiss (1) of the Argument from Perceptual Variation, the premiss stating that there is single object that appears different colours to different subjects. Disagreements about colour between pigeons and humans at least appear to be disagreements about the colour of the very same object. To suppose otherwise would lead to an unattractive mind-dependence of objects, let alone colours.

Nor is there any obvious non-arbitrary reason to prefer human colour vision to pigeon colour vision as veridically tracking the real colours of objects; it therefore doesn't look as though we can happily deny premiss (3) of the Argument from Perceptual Variation, either. Simply to privilege human colour vision would be chauvinistic and *ad hoc*. Indeed if anything, it might seem that we should prefer the more colourful pigeon vision to human colour vision, at least insofar as pigeons perceive more kinds of colour than humans: although we cannot automatically assume that the pigeon's colour perception is veridical in respect of the extra distinctions they make, the idea that there are distinctions to which we are insensitive is a familiar one; if so, then pigeons might stand to humans with respect to colours as sommeliers stand to those of us with less discerning palates where gustatory distinctions are concerned. To privilege pigeon colour vision, however, would undermine at least part of the motivation for attempting to resist the Argument from Perceptual Variation, which is to resist the perennially popular claim that our experience of objects as coloured is systematically misrepresentative. Privileging the colour experience of pigeons is at least consistent with the general claim that colour perception is not necessarily misrepresentative. But this is not really to the point: what we wanted was to justify the deliverances of *our* sensory experience.

Only slightly more promising in this respect is applying pressure to the inference from premiss (3) to the conclusion of the argument. Premiss (3) is the *epistemological* claim that we do not *know* of any non-arbitrary reason to prefer the deliverances of human colour vision to the deliverances of pigeon colour vision. The conclusion of the argument, however, is the *metaphysical* claim that objects *really* instantiate neither of the colours that they appear to. It is by no means obvious that this metaphysical conclusion follows from the epistemological premiss. At least pending further argument, it is consistent with the existence of a sharp appearance-reality distinction for the colours that objects really instantiate only one of the colours that they appear to, but *which* colour this is transcends our ideal means of verification.

To the extent that this response is plausible at all, it is on its strongest ground where the conflict amongst appearances is relatively localised. Members of the same species, for instance, might disagree about very specific colour classifications, as otherwise normal human perceivers notoriously do where unique colours, and unique green in particular, are concerned. But this disagreement at least typically coexists with a much more substantial agreement with respect to coarse-grained colour classifications. Where disagreement between perceivers is limited in this way, the problem posed by perceptual variation is at least contained, even if it does not dissipate entirely: although we might be unable to verify exactly which colours objects instantiate, there is not yet any reason to call into question the veracity of our course-grained colour ascriptions, and the existence of a class of unknown colour facts will therefore coexist with a much larger, and perhaps more important, class of facts about colour that are known (Byrne and Hilbert 2003). Still, even *if* this response is plausible in the intra-species case, the problem with inter-species variation—the problem which makes this *such* a troubling instance of the Argument from Perceptual Variation—is that between-species differences in colour perception are seemingly so great. Members of different species do not see objects as differing only slightly in colour. The differences go much deeper than this. If it were therefore to turn out that it is us humans who systematically misperceive the colours of objects, there would be no more general level of description to which we could retreat, at which our visual experience would still be veridical: except in the most general sense that objects which appear coloured really would be coloured, our colour experiences would be systematically misleading. And again, this would undermine the main motivation for defending the mind-independence of colour in the first place: to justify the deliverances of our sensory experience.

Premiss (1), premiss (3) and the inference from (3) to (4) therefore all appear in good standing. This just leaves premiss (2): the claim that the properties perceived by different subjects are incompatible. Is this any more promising a premiss to reject?

The Argument from Perceptual Variation is sometimes stated in such a way as to rule this response out of court at the outset. With corresponding substitutions of 'not-*F*' for '*G*' throughout, consider a version of the argument whose first premiss is:

> (1′) An object x appears *F* to subject S and appears not-*F* to subject S* (or: appears *F* to subject S in conditions C and appears *not-F* to S in conditions C*).

On pain of violating the law of excluded middle, and assuming that the reference of 'green' in the two uses is univocal, nothing can be simultaneously green and not-green. If (1′) describes the facts about variation that need to be accounted for, then premiss (2), the incompatibility claim, follows simply as a matter of

logical necessity. In this form, the Argument from Perceptual Variation would be fatal for the view that colours are mind-independent.

But (1′) does not adequately describe the facts that need to be accounted for; as such, (2) does not follow simply as a matter of logical necessity. Specifically, it does not follow from the fact that an object *does not appear green* to a pigeon that it thereby *appears not-green* to the pigeon, any more than it follows from the fact that because an object *does not appear* (what we might with a pinch of salt call) *pigeon green* to us, that it thereby *appears not-pigeon green*. The placement of the negation is critical: there is a crucial difference between something not appearing a certain way and its appearing not to be that way.

If, however, the Argument from Perceptual Variation is stated using premiss (1), rather than (1′), whether the properties that members of different species perceive are compatible is still an open question.

4. Determinates of Different Determinables?

Intuitively, property ascriptions are only incompatible if the properties ascribed are properties of the same kind; properties of different kinds are not mutually exclusive. For instance, although objects cannot simultaneously be circular and square, they can simultaneously be square and heavy, moving and tall, beautiful and morally abhorrent. The idea that I want to explore is that the colours that members of different species perceive also differ in kind in something like this way.

The distinction between determinates and determinables provides one way of sharpening the so far vague idea of sameness and difference of property kind. Associated with each determinable property are a number of "dimensions of determination" (Funkhouser 2006). Dimensions of determination are those respects in which determinates of a determinable differ: in the case of human-colour, for instance, hue, saturation and lightness. The determination dimensions associated with a determinable property jointly define a property space in which any determinate of that determinable can be located. Because no object can be differently determined along the same dimensions of determination at the same time, incompatibility in the ascription of determinate properties arises when the same object is assigned different sets of values along the same dimensions of determination; or in other words, when it is ascribed properties that occupy different regions of the same property space. Understood in these terms, the question of whether members of different species perceive properties that are incompatible can be reformulated as the question of whether members of different species perceive properties that can be located within the same property space.

It would be too quick to conclude that the properties perceived by members of different species are mutually compatible simply because they are associated with property spaces that differ in size. Whilst the space defined by the colour properties that pigeons perceive is larger than the space defined by

the colours that humans or cats perceive—at least insofar as tetrachromatic pigeons perceive more kinds of colour than trichromatic humans or dichromatic cats—bare difference in size of property space is not of itself sufficient for difference of determinable property. All but the most general properties are determinate or determinable only relative to some other property. Properties that are themselves determinate relative to a more general determinable, however, are mutually incompatible. Take yellow and red, which are determinable relative to lemon yellow and scarlet respectively, but themselves determinate relative to (human-)colour. An object cannot simultaneously be yellow and red. Determinates of the 'mid-level' determinables yellow and red vary along the same dimensions of determination, and consequently the property spaces associated with these determinables are both proper parts of the larger property space associated with the higher-level determinable property, human-colour. By parity of reasoning, if the determinable property human-colour is itself determinate relative to pigeon-colour, or perhaps if both are determinate to a still higher-level super-determinable property COLOUR, then determinates of these determinables will also be mutually incompatible. If human-colour is itself determinate relative to pigeon-colour, or both are determinate relative to COLOUR, then an object could not be both human-coloured and pigeon-coloured.

But is this the right way to think of the relationship between the colours that members of different species perceive? For human-colour to determine pigeon-colour, and both to determine a super-determinable COLOUR, human-colour space would have to be a proper subset of pigeon-colour space, and both would have to be a proper subset of COLOUR space. Given that the property space associated with a determinable property is defined by its dimensions of determination, this would mean that human-colours, pigeon-colours, and colours more generally, would all have to vary along the same dimensions of determination. The dimensions of determination along which human-colours and pigeon-colours vary, however, actually appear to be very different; as such, there is reason to suppose that the property spaces associated with human-colour and pigeon-colour are disjoint, and the properties located in these spaces mutually compatible.

Consider first the dimension of determination, hue. It is important to resist the temptation to think of pigeons as simply perceiving the same hues that humans perceive plus some extras, consequent upon their increased spectral sensitivity and more complicated visual processing mechanisms.

For a start, even in the region of the spectrum to which humans and pigeons are both sensitive, the colours that humans and pigeons perceive appear to differ markedly. Whereas humans generally perceive 540nms light as green-yellow, experiments by Wright and Cummings (1971) suggest that pigeons perceive spectral light falling either side of 540nms as completely different in hue. Whilst 540nms therefore marks a boundary between pigeon hues, it doesn't mark a boundary between human hues (Thompson 1995: 150-1).

Indeed, to say that 540nms marks a 'hue boundary' for pigeons already threatens to stretch the meaning of the word 'hue' to breaking point. Hue is standardly defined in terms of the human hues that lie around the human hue circle: according to the standardised definition produced by the International Commission on Illumination (the C.I.E.), for instance, hue is that "Attribute of visual sensation that has given rise to the colour names, such as: blue, green, yellow, red, purple etc" (CIE 45-25-040). By this definition, a dimension of determination along which there are colours that have no location on the human hue circle is not a dimension of hue at all.

Of itself, this definitional point does not go very deep. The C.I.E. definition of hue is best seen as an attempt to regiment colour vocabulary for use in narrowly circumscribed scientific and technological situations. It therefore cannot simply be taken as an authoritative guide to its use outside of those contexts. Indeed, it is worth noting in this respect that the C.I.E. definition itself betrays the scientist's latent eliminativism, defining 'hue' as 'an attribute of visual sensation', something which is inconsistent with the common sense use of colour terms to refer to attributes of mind-independent properties of material objects!

Still, there is an important underlying point which the C.I.E. definition, perhaps unwittingly, highlights. The hue circle is a closed space in which every region is occupied. This circular structure precludes the possibility of simply adding in any extra hues: there is no point on the human hue circle at which any extra hues can be slotted in (Westphal 1987: 100-1, Thompson 1992: 331-2). The only way to accommodate extra colours along the dimension of hue would be by widening the hue circle. Distances on the hue circle, however, represent in extrinsic spatial terms internal relations of similarity between the colours. These relations are standardly assumed to be essential relations, that at least partly determine a colour's identity: the similarity relations colours stand in are certainly sufficient to uniquely identify them in normal contexts (something reflected in the use dictionaries make of colour similarities to define colour terms), and appear to be sufficient to identify colours across all possible contexts, on pain of changing the subject; otherwise, it might seem that rather than thinking about a particular colour standing in a different set of similarity relations, we are really just surreptitiously thinking about the colour that actually stands in those relations.[2]

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[2] Byrne and Hilbert (2007b) describe the view that the relations of similarity and difference between the hues are essential to them as "in one version of another, something of a consensus view amongst philosophers". This is not to say that it is entirely uncontroversial (e.g. Cohen 2003). But far more controversial is what the properties that stand in these essential relations are: whether they are properties of mind-independent material objects (and if so, properties of what kind: are they themselves mind-independent or relational, physical or *sui generis* etc.); or if they are not properties of material objects, whether they are properties of the brain, the visual field, sense-data, experience itself, or non-existent properties represented in the content of experience? Just as the default assumption is that colours are properties of mind-independent material objects (and not properties of experience, etc.), I take it that the default assumption is that the similarities are similarities between properties of mind-independent objects. Byrne and Hilbert (2007b) themselves argue that in some relatively minimal sense, colour-blind humans perceive objects to be differently coloured to normal human perceivers: red-green colour blind subjects (for example) perceive objects to be yellowish and bluish, without thereby perceiving

Assuming that the similarity relations are essential to the colours, changing the distances on the hue circle changes the internal relations, and thereby the properties, that the hue circle represents. As such, the extra colours that pigeons perceive cannot be located on our hue circle. If pigeon-colour space is a three-dimensional space, then its third dimension is not hue.

One possibility at this point would be to move to a four-dimensional space in which to locate pigeon-colours: setting aside the empirical problems involved in identifying a common dimension of hue to human-colour space and pigeon-colour space suggested by the experiments of Wright and Cummings, it would still seem to be at least theoretically possible that pigeon-colour space is a four-dimensional space in which three of the four dimensions match those of human-colour space.[3] It is certainly true that not all determinable properties come with a fixed number of determination dimensions. Consider shape. Triangles, squares and pentagons are all shapes. Because these figures all have different numbers of sides, however, each figure requires a different number of determination dimensions, depending on how many sides it has. Again following Funkhouser (2006: 555-6), we can therefore say that at least some super-determinables come not with a limited number of determination dimensions, but with "a schema for producing such determination dimensions": in the case of shape, that for each side an object has, there is another determination dimension that represents that side's length. And clearly, if this is the right model on which to understand the relationship between human-colour and pigeon-colour, then the problem of colour incompatibility resurfaces: just as nothing can be simultaneously triangular and square, so nothing could be simultaneously human-coloured and pigeon-coloured.

But again, there is reason to resist this line of thought. First, it is important to stress that we cannot simply assume that the dimensionality of colour vision corresponds in any direct way with the dimensionality of phenomenal colour space. Specifically, it cannot simply be inferred from the fact that pigeon colour vision is tetrachromatic that pigeon-colour space—the space that describes pigeon-colours-as-perceived—is itself four-dimensional. The number of retinal receptor types a subject possesses determines the dimensionality of their vision, but not the nature of the colour experiences they enjoy; colour experience is also partly determined by the way the retinal signals are subsequently processed. By way of illustration, consider a dichromatic colour-blind human perceiver, who we

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them to be more determinate hues like unique yellow or orange. Even if we accept this description of the phenomenology (although see note 4), this appears to be consistent with the claim that the structural properties of the colours are essential to them; what they deny is just that determinate properties like yellow and orange, and thereby the relations of similarity and difference in which they stand, have to be represented in the content of experience.

[3] Compare Thompson's attempt to make sense of a human perceiver, Fred, who perceives novel colours: "whereas we are trichromats and have a colour space of three dimensions, Fred is a *tetrachromat* and has a four dimensional colour-hyperspace" (1992: 336). Note that Thompson does not have to contend with the problems raised by the Wright-Cummings experiments, because he is only considering the possibility of *human* perceivers who perceive extra colours. Indeed, elsewhere, Thompson makes a strong case for thinking that the colours that members of different species perceive are incommensurable.

can assume (standardly, but not uncontroversially) to be absolutely unable to perceive either red and green, or blue and yellow. Even so, this dichromat would still perceive colours that define a three-dimensional space, and arguably a space whose dimensions are hue, saturation and lightness at that: the achromatic lightness dimension is unaffected by colour blindness; the yellows and blues (or greens and reds) that the subject is able to see are qualitatively identical to hues that lie on the hue circle; and given that differences in the third dimension of colour space correspond to differences in the proportion, or strength, of a hue, then these yellows and blues (or greens and reds) must have some non-zero level of saturation, otherwise they would not be yellows and blues (or greens and reds) at all, but points on the achromatic lightness scale.[4]

But even if the dimensionality of pigeon colour vision does correspond directly to the dimensionality of pigeon-colour space, and therefore pigeon-colour space is a four-dimensional quality space, the suggestion that pigeon-colours stand to human-colours as squares stand to triangles faces a further problem: there is no analogue of a 'determination dimension schema' in the case of colour. In the geometrical case, the schema for producing dimensions of determination allows us to move between mid-level determinables simply by adding in dimensions of the same kind. In moving from triangles to quadrilaterals, for instance, we add in an extra determination dimension for the extra side that quadrilaterals have. This determination dimension does not differ in kind to the dimensions that are already in play, and in respect of which triangles vary; it is just an extra dimension of side length to correspond to the quadrilateral's extra side.

But we cannot move between multi-dimensional colour spaces in the same way. Just consider the three-dimensional human-colour space. The three dimensions of this space each differ fundamentally in kind. Were we to try to move to three-dimensional chromatic colour space from a one-dimensional achromatic colour space by adding in more dimensions of the same kind, we would add in dimensions with absolute beginning and end points, like the

[4] The standard assumption that colour-blind human subjects *are* absolutely unable to perceive either red and green, or blue and yellow, is in fact questionable. Colour blind subjects usually appear to experience only a greater or lesser degree of 'collapse' of the normal trichromatic colour space. Jameson *et al* (2001), for instance, found that red-green colour blind protanopes divide the visible spectrum into an average of 5.3 colours, in contrast to the average 7.3 colours into which normal trichromatic subjects divide it. Although there is a reduction in the number of colours that these subjects are able to perceive, it is inconsistent with the view that red-green protanopes perceive *only* blue, yellow and grey. This conclusion is supported by the experiments of Wachtler *et al* (2004), who found that red-green colour blind subjects were consistently able to use the full range of elemental hue terms (red, green, yellow and blue) to describe 2° patches of monochromatic light. Still more compelling evidence that people who are colour blind can perceive the same colours that normal trichromats perceive—given that there can be no suggestion that these results might be explained by exposure to trichromatic linguistic practices in normal contexts—is that colour experiences corresponding to those described by normal trichromatic subjects can be induced in colour blind subjects using Benham disks: disks that are half black and half white, and that when rotated at about 6-8Hz generate 'subjective colours' which appear as desaturated bands of different hues depending on the exact speed of the disk (Shepard 1992: 338-9). For a philosophical discussion of these issues see Broackes (2005); and for a slightly different perspective, Byrne and Hilbert (2007b).

achromatic dimension lightness that begins with black and ends with white. We cannot extrapolate the dimension hue in this way, however. The dimension hue is not conceptually bipolar, but circular: there are no absolute beginnings or endings, but each part eventually shades into every other. Unlike hue, saturation is at least a bipolar dimension of variation: colour samples vary from maximal saturation at the circumference of the hue circle to unsaturated at the central achromatic axis. Nevertheless, saturation is also a very different dimension of determination from both lightness and hue, something reflected in the fact that the dimensions of hue and lightness are conceptually much easier to grasp than saturation: whereas differences in lightness and hue are typically thought of as variations in 'colour', differences in saturation are more naturally thought of just as differences in one and the same 'colour'.

These considerations suggest that the determination dimension hue is unique to human colour space: the extra colours that pigeons perceive can neither be located on our hue circle, nor can they be accommodated on an extra dimension of determination, in such a way that human-colour space would be a proper part of pigeon-colour space. What about the other dimensions of determination?

Given that saturation is defined in terms of hue, saturation is unique to human colour space if and only if hue is. Whilst there might of course be analogues of saturation in different colour spaces, these dimensions will not be saturation itself.

Lightness presents more of problem, as we at least seem able to imagine a colour space that differs from ours in respect of hue and saturation, but which still contains the achromatic colours, black, white and grey. Nevertheless even here, the situation is far from straightforward.

The first thing to notice is that even if we grant that there could be a colour space that differs from ours in all its dimensions of determination except lightness, this would fall short of establishing outright the incompatibility of human-colours with colours of this other kind. It would not follow that human-colour space is a proper part of this colour space, or that both occupy regions of a still larger space associated with a super-determinable property, COLOUR. At best, it would show only that these spaces share a common dimension of determination.

But it is not clear that we should not even concede this much. Just because the achromatic colours that lie along the dimension of lightness enjoy a greater *conceptual* independence from the chromatic colours, it does not follow that they are thereby *metaphysically* independent. To suppose that there could be a colour space that differs from ours in respect of hue and saturation but which still contains the achromatic colours does not cut any ice against the view that the relations in which colours stand are essential internal relations; that colours could not but stand in precisely the relations in which they actually stand. On this view, all the act of conception amounts to is conceiving of certain human-colours that essentially bear internal relations to red, green, blue and so on, without at the

same time conceiving of these further human-colours. But of itself this does not support the claim that black, white and grey could be internally related to *other* colours (cf. Hilbert and Kalderon 2000: 206).

If this is right, then the dimensions of determination along which human-colours and pigeon-colours vary are *just different*. Given that determinable properties are defined by their dimensions of determination, this means that human-colour and pigeon-colour are themselves super-determinable properties; as W.E. Johnston, who coined the determinate-determinable terminology would say, they are distinguished by the complete "otherness" of their determinates (1921 i: 175-6). And if this right, then the colours that different species perceive are not, as the Argument from Perceptual Variation requires, incompatible. The correct conclusion to draw from the Argument from Perceptual Variation is therefore not that both sets of appearance are equally apparent. The correct conclusion to draw is that both sets of colour appearance are *equally real*.

5. Selecting Colours

The distinction between determinates and determinables represents one way of developing the idea that the colours perceived by members of different species differ in kind, but it is perhaps not the only way. The basic thought—at least as far as inter-species variation is concerned—is that premiss (2) of the Argument from Perceptual Variation is false: that, consistent with the mind-independence of colour, the colours that members of different species perceive are not mutually incompatible. What I want to do in the remaining sections is abstract away from the details of the determinate attempt to develop this determinable idea. Whatever the precise details, the general proposal raises a number of questions.

The first question is whether the denial of premiss (2) is consistent with the mind-independence of colour at all. Premiss (2) of the Argument from Perceptual Variation, for instance, is the premiss that relationalists about colour also reject. According to relationalists, colours are relational properties whose constituent relata include subjects, objects and conditions of perception. Whatever else this amounts to, a minimal commitment of the relationalist position is that a difference in relata entails a difference in relational property; hence that objects are differently coloured depending on the subject that perceives them and the conditions in which this perceptual encounter occurs. But this is precisely what proponents of the view that colours are mind-independent are committed to denying: if colours are mind-independent, then the way an object *appears* to different subjects in different perceptual conditions is independent of the colour the object *really* is. The first worry is therefore that the current response to the Argument from Perceptual Variation simply collapses into that of the relationalist.

The claim that members of different species perceive colours that differ in kind—no less than the specific version of this claim, that members of different species perceive determinates of different determinable colour properties—does not, however, entail the relationalist thesis. The generally pluralistic view that

objects simultaneously instantiate many different kinds of colour property is perfectly consistent with the claim that these properties are constitutively independent of the experiences of perceiving subjects. It might simply be that objects instantiate a plurality of mind-independent colour properties, only some of which are perceptually available to different subjects. On this view, different subjects *select* from amongst a pre-existing range of mind-independent properties which properties they perceive.

The basic selectionist insight can be developed in a number of ways: in this respect, selectionism is not so much a theory about the nature of colour as an umbrella term for a family of different theories (compare Cohen's (2004) remarks about its relationalist counterpart). Selectionist accounts of colour from a broadly speaking naturalistic perspective have recently been defended by Hilbert and Kalderon (2000), Kalderon (Forthcoming), and Mizhari (2006). Similar ideas were current amongst less naturalistically inclined sense-datum theorists in the first part of the twentieth century, who conjoined a commitment to the existence of sense-data with the claim that sense-data are mind-independent (for discussion, Price 1932: 39-54). Indeed, something at least akin to the selectionist idea goes back almost as far as the problem of conflicting appearances itself, to Heraclitus's response to Protagoras's relativism (Burnyeat 1980; Kalderon Forthcoming).[5]

The key to the selection metaphor is not to think of colours as in any sense 'springing into existence' in the presence of the experiences of appropriate perceiving subjects. As Kalderon emphasises, the selectionist thinks of perceptual experience as affording a merely partial perspective on the actual sensible properties of objects; the nature of the perceiving subject therefore merely determines which, out of the many actual properties objects instantiate, the subject selects. Borrowing an Aristotelian analogy, used in a slightly different context by H.A. Prichard (1909: 129), the selectionist thinks of the relationship of colour to colour perceiver as less like that of patient to doctor, and more like that of sick person to doctor: whereas the existence of a patient implies the existence of doctor whose patient he is, the existence of a sick man implies only the *possible* existence of someone to doctor him; in a similar vein, according to the selectionist, the existence of a family of colours does not imply the actual existence of an appropriate colour perceiver to select them, but only the *possibility* of an appropriate colour perceiver.

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[5] Cognate ideas appear elsewhere. Wiggins's claim that the identity and individuation of material objects depends upon the sortal concepts we use to think about them, for instance, is certainly selectionist in spirit. For Wiggins, to say that the individuation of objects depends upon the concepts that we possess is consistent with the claim that these objects are not metaphysically dependent on the existence of conscious subjects with our conceptual scheme. As Wiggins puts it: "what sortal concepts we bring to bear upon experience determines what we can find there – just as the size and mesh of a net determine, not what fish are in the sea, but which ones we shall catch" (2000: 152). A similar idea is perhaps implicit in Wiggins's accounts of colour and value in 'A Sensible Subjectivism?' (1987), and more explicit in his recent discussion of objectivity in ethics (2007). For a recent application of the selectionist approach to grammatical properties, see Longworth (ms.).

6. A Multiplicity of Colours

The selectionist attempt to avoid the spectre of relationalism in turn raises a number of further worries. The first is that the selectionist response to the Argument from Perceptual Variation proliferates colours beyond the bounds of common decency: whereas the relationalist is merely committed to the existence of a benign multiplicity of relational properties, ascribing multiple mind-independent colours is, by comparison, ontologically profligate.

It is unclear what, in the end, the proliferation worry really amounts to; I return to this below. But it is worth stressing in the first place that selectionism should not necessarily just be seen as a license to print money as far as colours are concerned.

Selectionism is presented here as a response to the inter-species version of the Argument from Perceptual Variation. This is not yet to say that objects instantiate a different colour corresponding to every possible colour experience. Like the parallel relationalist response to perceptual variation, the basic selectionist response can be, and has been, extended to account for different kinds of variation. Selectionism is presented by Hilbert and Kalderon, for instance, in response to intra-species perceptual variation, whilst the selectionist theories proposed by Heraclitus, early twentieth century sense-datum theorists, and more recently Mizhari, further generalise selectionism from cases of intra-species variation to cases of intra-subjective variation. The selectionist is not, however, committed to generalising their position in either of these ways.

It should at least be noted that the selectionist cannot employ the distinction between determinates and determinables in the way suggested in §4 if they *are* going to extend their account beyond inter-species differences: this specific version of the selectionist approach is therefore inconsistent with the response to intra-species variation proposed by Hilbert and Kalderon, and the still more general selectionist responses to intra-subjective variation. This response to the Argument from Perceptual Variation requires treating intra-species variation between normal perceiving subjects, and *a fortiori* intra-subjective variation, as fundamentally different in kind to inter-species variation: because the properties that normal human subjects perceive all occupy regions of the same property space, a space defined by the dimensions of determination hue, saturation and lightness, these properties are properties of the same kind, and so subject to mutual exclusion relations.

Problems associated with generalising the selectionist theory in either of these ways provides some independent motivation for restricting the selectionist response to cases of inter-species variation. (These problems mirror problems associated with generalised relationalist theories.) The extension of selectionism to the intra-subjective case, for instance, conflicts with standard accounts of colour constancy, according to which objects are perceived to remain constant in colour throughout variations in the illumination: whilst these accounts can account for perceived differences across perceptual conditions, they have difficulty accounting for the apparent sameness (see §7). The extension of selectionism to

the intra-species case, on the other hand, is consistent with standard accounts of colour constancy, but faces challenges elsewhere. First, there is a problem accommodating the possibility of intra-species *disagreement*. Even if some disagreements between perceiving subjects are faultless, it seems reasonable to suppose that at least some human subjects systematically misperceive colour; to suppose otherwise would seem to be political correctness gone mad. The challenge is to say what the relevant difference between the different kinds of case is. There is an equally pressing problem accommodating the possibility of *agreement*. Disagreements about very determinate colours notwithstanding, there seems to be a general convergence in colour perception amongst normal members of the same species. But how is this convergence possible if different individuals all perceive different families of properties? And related to this, how is successful communication about colour possible if colour terms refer to different properties on different subject's lips? (See Kalderon Forthcoming for some responses to these challenges; see also Cohen 2004 on the corresponding challenges facing the relationalist.)

The Argument from Perceptual Variation is often presented in such a way as to invite a unilateral response. The operative assumption is that different cases of perceptual variation present structurally analogous problems, and therefore demand structurally analogous solutions; hence that we should strive for consistency in our response to different versions of the Argument from Perceptual Variation, offering the same response across all possible cases. Yet it is far from obvious that variations in colour appearance that are the result of varying different kinds of factor really are just species of the same genus; hence that the problems posed by different kinds of perceptual variation really are structurally analogous. At any rate, the question certainly shouldn't be prejudged.

On the one hand, the assumption of uniformity threatens to prove too much, as it would appear to support Berkeley's entirely indiscriminate use of the Argument from Perceptual Variation: if all variations in colour perception are relevantly similar, then so, it might seem, are cases of perceptual variation involving paradigmatically mind-independent properties like shape, size and motion (although see Cohen 2004: §2.4).

But even just considering colour perception, there appear to be cases and cases. Broadly speaking, the factors that affect perceived colour fall into two apparently heterogeneous categories: differences in environmental conditions and differences in perceiving subjects. Within each of these categories, the relevant factors are seemingly quite disparate. Variations in the experience of an individual across radically different kinds of perceptual condition—say, in good natural daylight and artificial chromatic light—seem different in kind to variations in the experience of the same individual across perceptual conditions that would more naturally be described as 'normal', such as different phases of natural daylight, or artificial illuminants that approximate to natural daylight: whilst we might expect our colour experiences to be more or less veridical in the latter case, it hardly seems surprising that errors should arise in the former case (just as we

would not expect our experiences of shape and size to be veridical in perceptual conditions that are not broadly speaking normal, either). Likewise, there are intuitively important differences between otherwise normal subjects and subjects whose visual system is obviously malfunctioning, perhaps as result of physical bodily damage: again it seems very natural to assume that the experiences of the latter involve error in a way that the experiences of the former do not (again, compare shape and size perception). This case in turn seems different to more localised variations between otherwise normal perceivers—such as variations in the perception of maximally determinate unique hues—where the differences appear to reflect limitations of the visual system (just as we would expect to find differences amongst otherwise normal perceiving subjects in the perception of maximally determinate sizes). And this case seems different again to cases of variation between members of different species, which—given differences in physiology and evolutionary background— are perhaps more plausibly thought of as tracking different features of the perceptual environment.

Vindicating a piecemeal response to the different versions of the Argument from Perceptual Variation obviously demands detailed consideration of each case on its own merits. The important point here is just that a case can be made for thinking that different kinds of perceptual variation warrant different responses; because if the selectionist response is not extended beyond the inter-species case, then the selectionist's ontological commitments are reduced accordingly: the selectionist will not be committed to the existence of a different family of colours for every perceiving subject and every condition of perception, at most they will only need as many different families of colour as there are different species to perceive them.

Even if this piecemeal strategy can be sustained, of course, a general worry about proliferation remains: the world still turns out to be a more colourful place on the selectionist account than we might otherwise have thought. Independent of whether the selectionist response generalises, the more fundamental thing to say in response to the proliferation worry is therefore that it is not clear how seriously the selectionist should take this objection anyway. The bare fact that selectionism is, in this one respect counterintuitive, is not itself damning. As Price remarks in response to a similar objection: 'mere oddness can hardly be a difficulty. The material world is an odd place on any theory, and it certainly was not made for the convenience of philosophers' (1932: 46). More positively, the selectionist's proliferation of colours is at least consistent with strictures on qualitative economy, even if it violates principles of quantitative economy. Although there is a sense in which the properties that different subjects perceive differ in kind, there is (as I will argue in §7) a different sense in which these properties are nevertheless properties of the same kind. Postulating different colours for different species (and perhaps different colours for different subjects, or even different colours for different perceptual conditions) therefore does not increase the number of basic types of property in the world; the only increase in being is an increase in the number of tokens of this type. In this respect,

selectionism is merely what Kalderon (Forthcoming) calls a "conservative extension" of our common sense scheme (again compare Price 1932: 46.)

More fundamentally still, in whatever sense parsimony is a theoretical virtue, parsimony for parsimony's sake is not. It is not an advantage of a theory to get by with less if more is needed to adequately explain the phenomena that need to be explained. Needless to say, it is controversial what constitutes an adequate explanation of the facts about colour. Some people suppose that we can adequately explain everything that needs to be explained simply on the assumption that colours are properties of 'visual sensation' (recall, for instance, the C.I.E. definition of hue). Relationalists who are moved by the worry that colours appear to be properties of material objects and not properties of experience (or the brain, etc.), think that we can adequately explain everything that needs to be explained by identifying colours with properties of mind-independent material substances, albeit relational properties that objects bear to perceiving subjects and conditions of perception. Others find this explanation equally unconvincing. Anyone who thinks that colours appear to be fully-fledged mind-independent properties, and not merely relational properties of mind-independent material substances (or properties of experience, the brain etc.), will think that we cannot get by with anything less than the claim that colours are, as they appear to be, mind-independent. Selectionism allows us to take this appearance at face value. For the selectionist, the theoretical pressure to explain the character of our experience in terms of that which it is an experience of therefore justifies the ontological costs of the selectionist position.[6]

7. The Unity of Colour

Worries about ontological excess give way to a deeper worry. According to the selectionist, disagreements in colour perception across species are faultless because members of different species perceive properties that differ in kind. But if the properties that members of different species perceive differ in kind, then why say that they are *colours* at all?

It does not seem very plausible to say that these properties are not colours. Although comparative ecology is not an exact science, it would not be possible at all if other species did not have perceptual mechanisms that are at least in some sense similar to those found in humans, and it seems incredible to suppose that other species should use these essentially similar perceptual mechanisms to perceive properties that differ fundamentally in kind to the properties that humans perceive. But then what it is that these properties share, in virtue of which they can be grouped together as colours?

This problem is especially acute for the specific selectionist theory presented in §4. This view offers a very robust understanding of sameness or

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[6] This is something stressed by Kalderon (Forthcoming). I argue that we ordinarily think of colours as mind-independent in Allen (2007).

difference of property type: property instances are instances of the same property type if they vary along the same dimensions of determination, and so are both located in the same property space. This avoids the problem with generalised selectionist views of explaining in what sense property instances that vary along the same dimensions of determination can really be said to differ in kind. But explaining difference of property kind in this way makes it all the more difficult to justify the description of these properties as colours. It is often thought to be constitutive of what it is to be a colour that a property bear some internal resemblance relation to a property located within human-colour space. According to Hardin, for instance, to speak meaningfully of alien colours—"sensory qualities that may be said to have a hue, but a hue that is not identical with red, yellow, blue, green, or any of their binaries"—the alien colour must have an "appropriate resemblance relation" to human hues: the alien hue and at least one of the standard hues must "occur within the consciousness of an individual" (1988: 145). Thompson appears to impose a similar requirement when he claims that for a property that lies outside our colour space to be a colour, there must be "some resemblance route from our colour space to the novel colour space" (1992: 334-7; although for a slightly different interpretation, see Matthen 1999: 54). In saying that human-colours and the colours perceived by members of different species are determinates of different determinables, however, the existence of any internal resemblance between these colours is precisely what has been denied. Whereas human-colours bear internal relations of similarity to each other, and pigeon-colours bear internal relations of similarity to each other, I have argued that there are no internal relations of similarity between human-colours and pigeon-colours: if there were, then it should be possible to represent these colours in the same property space, in which case they would, according to the proposed account of sameness and different of property kind, be mutually incompatible after all.

The solution to this problem requires identifying similarities between the families of property that members of different species perceive that justifies describing them as colours, but which are not internal relations of similarity between their determinates. A few possibilities present themselves.

In the first place, similarities in the low-level perceptual mechanisms found across different species point to a similarity in the properties that these low-level perceptual mechanisms detect: physical light-reflecting, emitting, diffracting, (etc.) properties of material objects, light sources, liquids (etc). As such, these physical properties offer one way of grouping the properties perceived by members of different species together as colours. This is obvious if we accept the physicalist claim that colours are identical with these light-affecting properties (or their microphysical grounds). It is perhaps less obvious that a naïve realist—according to whom colours are *sui generis* properties, distinct from the properties described in a more or less narrowly circumscribed physical science—can also exploit this response (see, for instance, Byrne and Hilbert 2007a). But as long as the naïve realist accepts the supervenience of *sui generis* colours on physical

properties, there is no reason why this relationship cannot be exploited to forge a connection between different families of colour property. If colours supervene on physical light-affecting properties, then this relationship at least offers a necessary condition for grouping properties together as colours: a family of determinate properties will count as colours only if they supervene on an object's physical light-affecting properties.

Grouping together properties as colours on the basis of their relationship to physical properties provides a response to the unification problem, and might be the best that can be hoped for. Still, it is not entirely satisfactory. Part of what makes the condition on colour-hood proposed by Hardin, Thompson and others so attractive is the thought that an account of what it is to be a colour that leaves out what it is like to perceive that colour leaves out the most important part. Given the intimate connection between colours and colour experiences, it is natural to hope that there should be some feature of colours as perceived that justifies the description of these properties as colours. Indeed, it is precisely because he despairs of finding any way of arriving at an "adequate understanding of color by generalising from features of human experience" that Matthen (1999) concludes that colour is really a "disunity".

Still, there are at least some potentially promising conditions on what it is to be a colour that are phenomenologically informed, but which do not take the form of an internal resemblance relation between the colours; even if they are not ultimately necessary and sufficient, they certainly move in the right direction.

Similarities in the perceptual mechanisms that realise colour experiences, for instance, suggest one way of forging a closer connection between human-colour and pigeon-colour. In human colour vision, signals from the retinal receptors are opponently processed in three distinct psychophysical channels, realised by three distinct neurophysiological pathways. This opponent processing explains some particularly salient features of the phenomenology of colour experience, including the opponent structure of the colours and the related distinction between elemental and compound colours. Psychophysical evidence suggests that the retinal signals in other species, such as honeybees, goldfish and pigeons, are also opponently processed. If so, then although the colours represented in the experiences to which this processing gives rise may differ qualitatively to the human colours, these properties will still exhibit the same general structural properties as the human-colours: they will be opponently organised and divisible into mutually exclusive elemental and compound categories (cf. Thompson, as discussed by Matthen 1999: 54).

It is unclear whether exhibiting structural features of this kind is either a necessary or a sufficient condition for being a colour. It might not be necessary, because it may be nothing more than a contingent fact that humans, honeybees, goldfish, pigeons (etc.) perceive properties that are opponently organised: to the extent that we can conceive at all of what it would be like to experience colours that lack a location in human-colour space, it seems that we might be able to conceive of creatures perceiving properties that bear the relevant relation to the

underlying light modifying physical properties, but which exhibit neither opponent organisation nor the related distinction into elemental and compound. Conversely, it seems conceivable that there could be creatures that perceive properties instantiating structural features similar to the colours, but which are not appropriately related to physical light affecting properties at all.

Still, even if this condition is neither necessary nor sufficient, the link between colours and light suggests an alternative condition on what it is to be a colour that seems to fare better. On the face of it, the intimate relationship between colours and light is as much a part of the phenomenology of colour experience as the internal similarity relations between determinate colours and the opponent structure of the hues. As properties of material objects, colours typically exhibit perceptual constancy. A natural, and fairly standard, characterisation of colour constancy is that we perceive objects' colours to remain constant throughout variations in the illumination, despite changes in their appearance. Although it is not uncontroversial, this characterisation of colour constancy will at least appeal to anyone worried about the threat that inter-species variation poses to the mind-independence of colour in the first place, as this understanding of colour constancy provides one of the main sources of motivation for the view that colours are mind-independent: the constancy of colour throughout variations in an object's appearance across illumination conditions is, in effect, a manifestation of the distinction between the colour an object merely *appears* and the colour that it *really* is.[7] The further condition on being a colour that colour constancy suggests is that a family of properties count as a family of colours if, when seen as properties of material objects, their appearance is particularly sensitive to, and yet they exhibit constancy with respect to, changes in the illumination.[8] This apparently phenomenological characterisation of what it is to be a colour fits well with the fact that colours are

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[7] As part of his defence of a relationalist theory of colour, Cohen (2004) argues for a 'counterfactualist' account of colour constancy, according to which colour constancy is not a literally perceptual phenomenon: we do not actually *perceive* colours to remain constant as the perceptual conditions vary, but merely *judge* that an object would look a certain way in a certain counterfactual situation. Cohen's argument for this view turns on the claim that the *judgement* that coloured objects are in some way the same and yet in some way different as the perceptual conditions vary, cannot be grounded in the *perception* of coloured objects as in some way the same and yet in some way different as the perceptual conditions vary. This claim is questionable. In particular, it is not clear why perceiving an object as different in one respect should preclude perceiving it as being the same in some other respect; it is certainly not being assumed that we perceive (say) a white object in shadow *to be* both white and grey: rather we perceive it to be a white object that (merely) looks grey in this light (cf. Hilbert 2007). But even if Cohen's account of colour constancy is correct, something at least in the spirit of the constancy condition for colour-hood can be salvaged: properties can be grouped together as colours in terms of the immediately post-perceptual judgments of perceiving subjects. This similarity would not be *directly* grounded in the phenomenology of experience, but it would not be far off.

[8] Other properties such as shape and size do not count as colours according to this criterion because although they exhibit *perceptual* constancy, they do not exhibit *colour* constancy. Colour constancy differs from other kinds of perceptual constancy in respect of the feature of the perceptual conditions to which colour appearance is peculiarly sensitive: whereas colour appearance is sensitive to the nature of illumination (and a lesser extent the colour of the background), shape appearance is sensitive to an object's orientation with respect to the eye, and size appearance is sensitive to the distance of the object from the eye.

intimately related to the way in which material objects reflect light. Moreover, it is a characterisation that appears to get the extension of the concept colour right, at least insofar as the properties perceived by many of the species to which we want to attribute colour vision satisfy this condition: for instance, bees, fish, and pigeons all appear to exhibit signs of colour constancy (Neumeyer 1998).

Although this is a sufficient condition for being a colour, there might be doubts about its necessity. One problem is that it implies that even if they have perceptual mechanisms that are sensitive to light, creatures that exhibit only very low levels of colour constancy, or perhaps no colour constancy at all, do not perceive colours. This might seem *ad hoc*.

Still, there is at least some room to manoeuvre here. It seems fair to say that some of the simplest creatures that display sensitivity to variations in light, without exhibiting any significant degree of constancy, probably lack any phenomenology at all (Hilbert 1992); indeed, it is an open question whether even all those creatures that exhibit constancy enjoy anything that can reasonably be described as 'perceptual experience'. But if there is no phenomenology in the first place, then there are independent grounds for denying that these creatures are colour perceivers.

It might still seem conceivable that there are creatures who do not exhibit constancy, but who nevertheless enjoy something recognizably experiential: if there were, then the constancy condition implies that the properties that they perceive are not colours. But even here matters are not entirely straightforward. It is worth emphasising quite how dissimilar from our own the experience of these other creatures would be. It might be suggested, for instance, that we can imagine a non-colour constant creature's experience of the world simply by analogy with our experience of the evanescent plumage of birds, or the swirling colours on the back of a CD. But we perceive these kinds of colours (traditionally called 'apparent' or 'fantastical' colours) against the background of a stably coloured world. If *all* the colours we perceived were like this, then the world would seem very different indeed; perceiving the world in this way might even do irreparable damage to our concept of a mind-independent material object, as our ability to identify and reidentify material objects appears to be bound up with our ability to identify their persisting characteristics, of which colour is an important example (reference omitted). In light of these dissimilarities, it might be that we can simply deny that the properties that non-constant creatures perceive really are colours. Of course, these creatures might perceive something *like* colour, but it is not clear that we *have* to describe them as perceiving colour as such. These properties do not have a place in our quality space; they do not exhibit one of the most important characteristics of the colours, constancy; and insofar as they do not exhibit constancy, there are important differences in the perceptual mechanisms that realize the experiences of these properties. As the pressure to unify the properties perceived by members of different species in the first place comes from cross-species *similarities*, it is not quite so incredible to suppose that these properties are not colours.

A related worry about the necessity of the constancy condition on colour-hood arises from the fact that other creatures appear to use colour vision for functions other than perceiving the constant properties of material objects (cf. Thompson 1995: 177-88, Matthen 1999). Pigeons, for instance, appear to use their ultra-violet colour vision as a navigational tool to identify directions in three-dimensional aerial space: because of the way in which light is scattered in the atmosphere, light coming from a direction perpendicular to the sun is strongly weighted towards short-wavelength ultraviolet frequencies, whereas light travelling from the direction of the sun is more evenly spread across the electromagnetic spectrum. This suggests that pigeons see directions, in addition to material objects, as coloured (Nuboer 1986; Thompson 1995: 172 and Matthen 1999: 60-1). Tying colour perception too closely to the perception of constant object colours threatens to exclude these other properties from being colours. And this too might seem *ad hoc*.

But again, there is at least some room to manoeuvre. As in the case of non-constant colours, one option is simply to deny that the properties in virtue of which pigeons identify directions are strictly speaking colours at all. They might be *like* colours, but it is not clear that we have to describe them as colours as such.

A more concessive response—and one that could perhaps be extended to cover non-constant properties as well—is to accept that they are colours, but explain their status as colours in terms of resemblance relations to constant properties of material objects. The fact that the mechanisms subserving colour perception can be used to perceive properties that are not properties of material objects does not of itself show that creatures that use their perceptual mechanisms in this way are not perceiving colours. Whilst pigeons might perceive directions as coloured, they also perceive material objects as coloured. Indeed, we know from our own experience that it is not just material objects that appear coloured: so do light-sources, liquids, and the sky (cf. Matthen 1999: 64). Perhaps the status of these further properties as colours is parasitic on their appropriately resembling properties of material objects: for example, the sky is blue in virtue of being phenomenally similar to denim jeans, directions in aerial space are 'ultra-violet' in virtue of being phenomenally similar to a some kind of material object, and so on.

This approach is still vulnerable to the worry that there might be creatures that *only* used their perceptual mechanisms to perceive properties that are not properties of material objects. Again, it is far from clear that we can really conceive of what this would be like. Nevertheless, these creatures can be included within the class of colour perceivers so long as the properties that they perceive appropriately resemble constant properties of material objects that they *would* perceive in the relevant circumstances. The postulation of constant properties of objects corresponding to the non-object colours these creatures actually perceive is consistent with the selectionist's liberal ontological attitude. Moreover, it is in keeping with selectionist's insistence that perceptual experience offers a partial perspective on the sensible qualities of the

environment; in this case, the perspective is just slightly more partial than in others.

8. Conclusion

I have argued that inter-species variation in colour perception does not undermine the mind-independence of colour, because disagreements between members of different species are faultless: members of different species perceive determinates of different, mutually compatible, determinables. This proposal is an instance of the selectionist approach to colour perception, according to which perceptual experience offers a partial perspective on the sensible properties of the perceptual environment, with different subjects selecting the colours they perceive from amongst many mind-independently existing options. In the face of problems posed by inter-species variation in colour perception, selectionism offers a way of defending the claim that colours are, as they appear to be, mind-independent.[9]

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